Chapter 9

Report Conclusions

Achieving food security—ensuring that an adequate amount of nutritious food is available, accessible, and usable for all people—is a widely shared global objective, most recently codified in the 2030 Agenda for Sustainable Development (UN General Assembly 2015). The quest for universal food security is one of the greatest human development challenges facing the world, despite significant progress in recent decades.

There were about 1.01 billion people who were estimated to be food insecure in 1990–1992, or 19% of the global population at the time. This number has fallen to about 805 million people today, or 11% of the global population (FAO et al. 2014). Hence the number of food-insecure people in the world has been reduced by about 20%, with the proportion almost halved in the last quarter-century, but at least 2 billion live with insufficient nutrients (Pinstrup-Andersen 2009) and about 2.5 billion are overweight or obese (Ng et al. 2014), though not necessarily receiving adequate nutrition. Food insecurity is widely distributed, afflicting urban and rural populations in wealthy and poor nations, and is particularly acute for the very young, because infant and child malnutrition results in damaging lifelong health and economic outcomes.

Can recent progress in reducing hunger be maintained or even accelerated when climate change is added to this set of problems? Global average temperature has already increased by about 0.8 °C since 1900 and further change is projected over the next century (Stocker et al. 2013). Global average temperature is projected to increase by another 1–2 °C by 2050 and 1–4° C by 2100, with accompanying increases in precipitation, precipitation intensity, floods, extreme heat events (day and night), droughts, and sea level, as well as changes in precipitation patterns, and decreased soil moisture (Stocker et al. 2013). This report has examined the potential effects of such changes on food security, with detailed findings presented in the summaries of each chapter. Our main conclusions are presented here.

Climate change is very likely to affect global, regional, and local food security by disrupting food availability, decreasing access to food, and making utilization more difficult. Climate change is projected to result in more-frequent disruption of food production in many regions and increased overall food prices. Climate risks to food security are greatest for poor populations and in tropical regions. Wealthy populations and temperate regions that are not close to limiting thresholds for food availability, access, utilization, or stability are less at risk. Some high-latitude regions may actually experience near-term productivity increases due to high adaptive capacity, CO_2 fertilization, higher temperatures, and precipitation increases. However, damaging outcomes become increasingly likely in all cases from 2050–2100 under higher-emissions scenarios.

The potential of climate change to affect global food security is important for food producers and consumers in the United States. The United States is part of a highly integrated global food system: climate-driven changes in the United States influence

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other nations, and changes elsewhere influence the United States. The United States appears likely to experience changes in the types and cost of foods available for import. The United States is similarly likely to experience increased demand for agricultural exports from regions that experience production difficulties yet have sufficient wealth to purchase imports; the United States is likely to be able to meet increased export demand in the near term. Demand for food and other types of assistance from the United States could increase in nations that lack purchasing power. In the longer term and for higher-emissions scenarios, increased water stress associated with climate change could diminish the export of "virtual water" in agricultural commodities. Climate change is likely to increase demand from developing nations with relatively low per hectare yields for advanced technologies and practices, many of which were developed in the United States.

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Climate change risks extend beyond agricultural production to other elements of global food systems that are critical for food security, including the processing, storage, transportation, and consumption of food. Production is affected by temperature increases; changes in the amount, timing, and intensity of precipitation; and reduced availability of water in dry areas. Processing, packaging, and storage are very likely to be affected by temperature increases that could increase costs and spoilage. Temperature increases could also make utilization more difficult by increasing food-safety risks. Sea-level rise and precipitation changes alter river and lake levels, and extreme heat can impede waterborne, railway, and road transportation. Constraints in one component of food security may often be compensated through another—for example, food insecurity may be avoided when production decreases *(availability)* are substituted with food acquired through purchase *(access)*. Alternatively, constrictions at one point within the food system may be so severe or have no feasible alternative possibilities within a local context such that food security may be compromised—for example, a country with ample food production but inadequate transport conduits has more limited capacity for food purchases by remote populations. As a consequence of these interactions and dependencies, a systems-based approach is needed to understand the implications of climate change.

Climate risks to food security increase as the magnitude and rate of climate change increases. Higher emissions and concentrations of greenhouse gases are much more likely to have damaging effects than lower emissions and concentrations. Worst-case projections based on high GHG concentrations (~850 ppm), high population growth, and low economic growth imply that the number of people at risk of undernourishment would increase by as much as 175 million above today's level by 2080. The same socioeconomic conditions with GHG concentrations of about 550 ppm result in up to 60 million additional people at risk, while concentrations of about 350 ppm—less than today's level—do not increase risk. Scenarios with lower population growth and more-robust economic growth result in large reductions in the number of food-insecure people compared to today, even when climate change is included, but higher emissions still result in more food insecurity than lower emissions.

Effective adaptation can reduce food-system vulnerability to climate change and reduce detrimental climate-change effects on food security, but socioeconomic conditions can impede the adoption of technically feasible adaptation options. The agricultural sector has a strong record of adapting to changing conditions. There are still many opportunities to bring more advanced methods to low-yield agricultural regions, but water and nutrient availability may be limiting in some areas, as is the ability to finance expensive technologies. Other promising adaptations include innovative packaging and expanded cold storage that lengthens shelf life, improvement and expansion of transportation infrastructure to move food more rapidly to markets, and changes in cooking methods, diets, and purchasing practices.

The complexity of the food system within the context of climate change allows for the identification of multiple food-security intervention points that are relevant to decision makers at every level. The future need for, and cost of, adaptation is lower under lower emissions scenarios. Trade decisions could help to avoid large-scale price shocks and maintain food availability in the face of regional production difficulties such as drought. Improved transportation systems help to reduce food waste and enable participation in agricultural markets. Public- and private-sector investments in agricultural research and development, coupled with rapid deployment of new techniques, can help to ensure continued innovation in the agricultural sector. Refined storage and packaging techniques and materials could keep foods safer for longer and allow for longer-term food storage where refrigeration is absent and food availability is transient.

Accurately projecting climate-change risks to food security requires consideration of other large-scale changes. Ecosystem and land degradation, technological development, population growth, and economic growth affect climate risks and food-security outcomes. Population growth, which is projected to add another 2 billion people to Earth's population by 2050, increases the magnitude of the risk, particularly when coupled with economic growth that leads to changes in the types of foods demanded by consumers. Sustained economic growth can help to reduce vulnerability if it reduces the number of poor people and if income growth exceeds increases in food costs in vulnerable populations. Analyses based on hypothetical scenarios of sustained economic growth and moderate population growth without climate change suggest that the number of food-insecure people could be reduced by 50% or more by 2040, with further reductions over the rest of the century. Such analyses should not be misinterpreted as plausible projections, since climate change is already occurring, but they clearly indicate that socioeconomic factors have large effects on food security and that these effects can either offset or amplify the effects of climate change. In the end, climate change and socioeconomic change must be analyzed in an integrated way to provide a full understanding of how food security might change in the future.

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